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THE FEASIBILITY AUTHENTIC ASSESSMENT INSTRUMENT THROUGH VIRTUAL LABORATORY LEARNING AND ITS EFFECT ON INCREASING STUDENTS' SCIENTIFIC PERFORMANCE

Muhammad Yakob,
Ratih Permana Sari,
Molani Paulina Hasibuan
Nahadi Nahadi,
Sjaeful Anwar
R. Ahmad Zaky El Islami

Abstract. *In the virtual laboratory learning process, students' scientific abilities in solving a problem are very important to explore. This study aims to develop classroom-based authentic assessment instruments through virtual laboratory learning in chemistry to see an increase in students' scientific performance. The research was conducted at a public high school in Langsa City with a sample of 11th-grade students Academic Year 2021/2022, the utilized subjects being a total of 118 students taken based on purposive sampling. The research data are needs analysis through interviews with chemistry teachers who have implemented technology-based learning, analyzing the feasibility of instruments through expert validation questionnaires before the learning process, and scientific performance through learning observation sheets during the learning process. The increase in students' scientific performance data was then analyzed using the N-Gain formula and t-test to see the difference in improvement after the authentic assessment was applied. The results show that authentic assessment is feasible to use an increase in students' scientific performance. From the small-scale test, the students' scientific performance was a high category and there is a significant difference in improvement. The use of authentic assessment through virtual laboratories is expected to provide active learning solutions to improve student learning outcomes.*

Keywords: *authentic assessment, expert validation, scientific performance, virtual laboratory*

Muhammad Yakob, Ratih Permana Sari, Molani Paulina Hasibuan
Samudra University, Indonesia
Nahadi Nahadi, Sjaeful Anwar
Indonesia University of Education, Indonesia
R. Ahmad Zaky El Islami
Sultan Ageng Tirtayasa University, Indonesia

Introduction

Assessment is an integral part of the educational process, which is used to observe and analyze the achievement level of students regarding their expected learning outcomes. This is applied to determine whether the learning process is in line with the expected objectives or still requires development and improvement. The nature of the assessment is to look for information that has been obtained and then provide quality feedback to improve future performance. While both processes involve collecting data about work performance or product, what is done with those data in each process is substantially different and evokes very different mindsets. Assessment for learning programs is based on the premise that formative assessment guides and facilitates learners in reaching their full potential (Ewim & Opateye, 2021). In this condition, assessment plays an important role in achieving an active collaborative learning environment, providing formative and summative data for both teachers and students.

Some of the findings of the application of assessment in the learning process have been carried out including the application of integrated technology in formative assessment to improve students' conceptual knowledge skills and motivation in chemical equilibrium material (Hagos & Andargie, 2022). Although it can increase knowledge and motivation, this formative assessment has not been able to reveal students' scientific performance because the process of giving feedback takes a long time. In the applied curriculum, learning assessment is used to measure the level of cognitive abilities and all other aspects of skills, such as thinking skills and scientific performance skills. Some students improve their metacognitive skills by observing learning processes. Students improve their problem-solving thinking, strategies, and solution creation through discussion and trial-and-error. Furthermore, students enjoyed learning and communicated well in groups by posing questions to solve problems (Anwari et al., 2015). Research centered on developing scientific performance

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has been carried out by (Cruz Neri et al., 2021; Price et al., 2010) but this study has limitations in comparing scientific performance at the beginning of learning and the end of learning. Assessment of the overall learning process has been conducted but only at the basic institutional level (Ibarra-Sáiz et al., 2021).

The condition that is often found today is that the assessment of learning conducted in class only emphasizes mastery of the concepts taught by written objective and subjective tests. The tests carried out only measure mastery of the material and evaluate low-level cognitive domains (Millah et al., 2021). Survey findings indicate that to determine teachers' needs for authentic assessment of Grade 8 writing skills, teachers require various types of evaluation, including writing samples, process writing, portfolio, performance assessment, journal, and projects/exhibitions (Refnaldi et al., 2017; Ulhasanah et al., 2020).

Research limitations explain that authentic assessment instruments display complicated task details while teachers need simple assessment rubrics. The results of a complicated rubric also show the reasons teachers are reluctant to carry out learning activities that focus on developing students' attitudes and scientific performance skills (Azzahra & Simatupang, 2021). An assessment that can assess all aspects of student learning outcomes (which are included in the cognitive, affective, and psychomotor aspects) both as a result of learning processes, as well as in the form of changes and developments in activities, and the acquisition of learning during the learning process takes place in the classroom and outside the classroom with authentic assessment (Hanifah & Irambona, 2019; Sukma et al., 2022).

Authentic assessment requires students to work in certain concrete and meaningful situations (Miller & Konstantinou, 2022; Nguyen & Phan, 2020). According to this authentic assessment, not much is applied appropriately in learning. More than half of the teachers polled stated that the assessments were not properly designed, implemented, or processed. The picture remains that the most extensive implementation of learning assessments in schools is still the dominant type of assessment tool used, such as writing tests (Hanifah & Irambona, 2019; Karunanayaka & Naidu, 2021). The results of the study also explain that most teachers have not mastered authentic assessment instruments and the instruments are not suitable for expressing student performance skills.

Based on previous research, it is necessary to design authentic assessments that have been validated so that teachers in schools can apply them. In addition, it is also necessary to apply learning activities that can express student performance skills by adding technology to the learning process. Laboratory-based learning is a way to reveal student performance skills. The role of laboratory is important in building students' skills and knowledge (Agustian, 2019; Agustina & Churiyah, 2019; Seery et al., 2019). There have been many uses of virtual laboratories (Ali et al., 2022; Tatli & Ayas, 2010; Yildrim, 2020), each of which applies to science learning. Design and development of virtual laboratories oriented to education can improve motivation to perform the various practices in the laboratory (Billah & Widiyatmoko, 2018; Evstatiev et al., 2022; Sahroni et al., 2020; Tüysüz, 2010). The results of the literature review show that the virtual laboratory is an interactive learning solution that can make it easier for students to understand abstract concepts to become more real, but no one has yet revealed an increase in scientific performance.

The aim of this research is to find how teachers need material for implementing virtual laboratories, how teachers apply authentic assessments in schools and what obstacles teachers face during the assessment process, and how they influence students' scientific performance improvement when virtual laboratory learning is applied. The aim is to find out the materials needed that apply virtual laboratories, find out authentic instruments that are suitable for use, and increase student scientific performance.

Research Methodology

General Background

In this research, the background includes an analysis of material needs that allows a virtual laboratory to be held as a basis for implementing authentic assessments, the feasibility analysis of several validators, and data analysis of scientific performance. The contribution of this research does not only come from virtual experiments and group discussions but also from evaluating the application of authentic assessments with more possible obstacles encountered in the field to suggest future research needs. The research data are needs analysis through interviews with chemistry teachers who have implemented technology-based learning, analyzing the feasibility of instruments through expert validation questionnaires before the learning process, and scientific performance through learning observation sheets during the learning process. Qualitative data in the form of descriptions of student responses are given at the end of the lesson to see the achievement of authentic assessment implementation.

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Participants

Participants were from 3 public schools comprising 3 chemistry teachers and 11th-grade students academic year 2021/2022 totaling 118 students from the best schools in Langsa City, Aceh Province. The average age of students participating in this study was 16 years old and there were 55 males and 63 females. The age of the teacher participants ranged from 26 years to 40 years with similar background qualifications. Gender was not considered for teachers as it did not feature in the research questions for this study. The study was conducted for four weeks during the teaching process using PhET interaction simulation applications on https://phet.colorado.edu/ in topic chemistry on https://phet.colorado.edu/en/simulations/filter?subjects=chemistry&type=html,prototype. The expert validator participants came from 1 well-known university in Aceh Province consisting of 3 chemistry lecturers aged 30-50 years who have experience as validators of chemistry education research.

Instrument and Procedures

The instrument for analyzing the needs of chemistry virtual laboratory learning materials is in the form of a questionnaire consisting of indicators of conceptual understanding, procedural complexity, and lack of sufficient resources. The needs analysis questionnaire sheet is given at the time before designing an authentic assessment. The results of the needs analysis data become a reference for materials that will be used as teaching materials using a virtual laboratory. After the needs analysis stage, the researcher continued the formulation stage of the authentic assessment instrument grid for media expert and material expert assessment tools as well as product practicality instruments at the expert validation stage. The details of the categories in the media expert validation instrument, materials, and product practicality tests can be seen in Table 1.

Table 1
Details of Research Instrument Categories

Subject	Categories of validity and practicality
Media expert	Relevance, Completeness, Accuracy, and Clarity
Material expert	Completeness, Legibility, Clarity, Appropriateness, and Accuracy
Practitioners	Accuracy (Effectiveness and Efficiency), Practicality, Clarity, and Completeness

Using observation sheets and activity assessment rubrics, an authentic assessment instrument model is used to measure student activity in understanding scientific performance. This assessment is directly conducted during the learning process, from start to finish. Authentic student assessment is carried out in the science laboratory room for 2 hours a week and lasts 8 weeks. Scientific performance data were obtained through observation sheets, by setting the highest and lowest values of 5 and 1, respectively, with the indicator and scoring rubric shown in Table 2.

Table 2
Rubric for Assessing Student Scientific Performance

Indicator	Rated aspect	Rubric	Score
Formulating problems	Proper use of laboratory safety equipment	Students use safety equipment completely and correctly	5
		Students use safety equipment correctly and incomplete	3
		Students use safety equipment incorrectly and incompletely	1
	Preparation of practical tools and materials	Students prepare tools and practicum materials completely and correctly	5
		Students prepare tools and practicum materials correctly and incomplete	3
		Students prepare tools and practicum materials that are not correct and incomplete	1

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Indicator	Rated aspect	Rubric	Score
Formulating predictions	Planning of work procedures	Students plan work procedures completely and correctly	5
		Students plan work procedures correctly and incomplete	3
		Students plan work procedures incorrectly and incompletely	1
Formulating experimental variables (responses, manipulative, and control)	Filling in the work practicum observation table using PhET simulation on https://phet.colorado.edu/	Students fill in the observation table completely and correctly	5
		Students fill in the observation table correctly and incompletely	3
		Students fill in the observation table incorrectly and incompletely	1
Formulating operational definitions of experimental variables	Filling in the results of work practicum observations using PhET simulation on https://phet.colorado.edu/	Students fill in the observations completely and correctly	5
		Students fill in the observations correctly and incomplete	3
		Students fill in the results of observations that are not true and incomplete	1
Communicating experimental data in the form of tables or graphs	Determination of observation results using formulas and graphs	Students determine the results of observations completely and correctly	5
		Students determine the results of observations are correct and incomplete	3
		Students determine the results of observations are not true and incomplete	1
Analyzing experimental data	Analysis of experimental data results	Students analyze the observations completely and correctly	5
		Students analyze the results of observations that are correct and incomplete	3
		Students analyze the results of observations that are not true and incomplete	1
Making conclusions	Conclusion of the final result of the observation	Students conclude the observations completely and correctly	5
		Students conclude that the observations are correct and incomplete	3
		Students conclude that the observations are incorrect and incomplete	1

Student responses to authentic assessments use response questionnaires. Student response data were obtained using a questionnaire consisting of indicators of accuracy (effectiveness and efficiency), practicality, clarity, and completeness. Student response questionnaire sheets are given at the end of learning to see the effectiveness of implementing authentic assessments in improving student scientific performance. In this condition, the data obtained include virtual laboratory material data, validation data, student scientific performance assessment data, and student response questionnaire data.

Data Analysis

The need for virtual laboratory learning material, authentic instrument feasibility questionnaire data were analyzed by calculating the percentage. In this condition, validity is the extent to which the measurement function of a measuring instrument is carried out, based on its suitability and accuracy (Feereira, 2016; Zacharis, 2010). The increase in students' scientific performance is observed from the pre-test and post-test scores using the N-Gain formula. In this condition, the calculation formula adopted the opinion of (Guntara, 2021), where data processing and analysis were carried out by subtracting the final scientific score from the initial (N_{B-N_A}). This was divided by the ideal scientific work minus the initial (N_{MAX-N_A}) and multiplied by 100%. Basic descriptive statistics (*N*, *M*, *SD*) of the numerical variables were determined. An independent sample *t*-test was used to analyze the difference in the pre-test and post-test of the students' scientific performance. In addition, the significance level of the independent sample *t*-test in this research was set to $p = 0.5$.

Research Results

Quantitative Results

According to the interviews with 3 chemistry teachers in Table 3, acid-base material represented 84.3% of the material needed for student assessment. This is due to the frequent evaluation of the acid-base topic at national exams.

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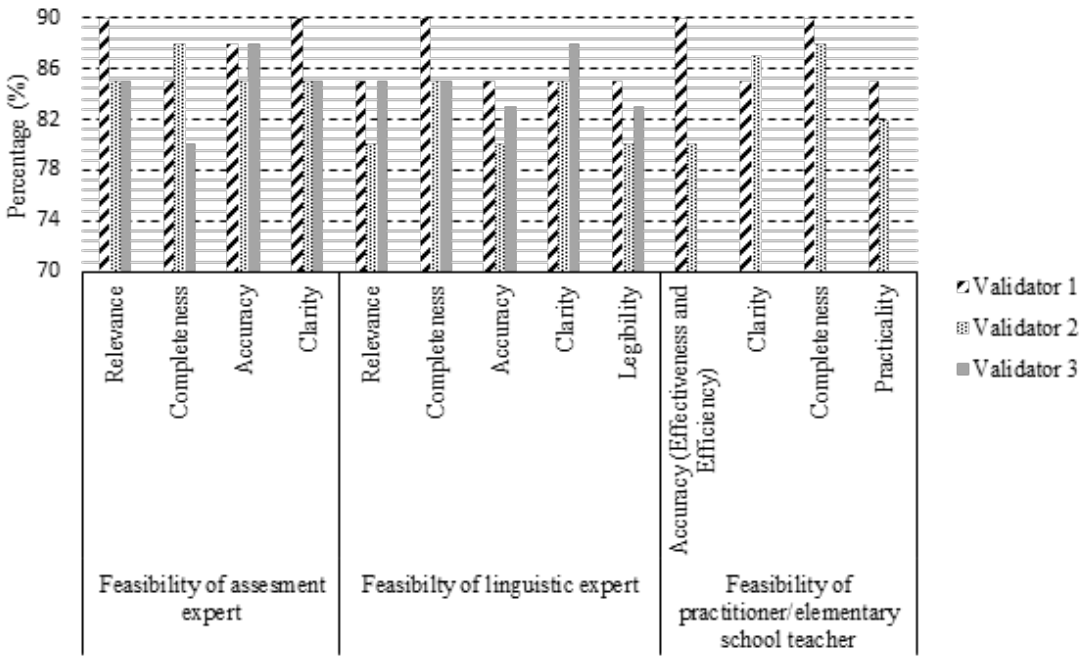
Table 3
Data Analysis of Authentic Assessment Needs

Learning materials	Factors (%)									Average level of need (%)
	CU			PC			SR			
	Respondents									
	1	2	3	1	2	3	1	2	3	
Acid-base	80.0	80.0	80.0	83.0	87.0	85.0	88.0	88.0	88.0	84.3
Substance purification	73.0	77.0	75.0	72.0	80.0	76.0	78.0	78.0	78.0	76.0
Chemical reactions	80.0	86.0	83.0	80.0	74.0	78.0	78.0	82.0	80.0	80.0
Solution stoichiometry	82.0	88.0	85.0	77.0	83.0	80.0	86.0	80.0	83.0	82.7
Thermochemistry	77.0	77.0	77.0	81.0	75.0	78.0	70.0	76.0	73.0	76.0

Note: CU = Conceptual Understanding, PC = Procedural Complexity, SR = lack of Sufficient Resources

The feasibility results of authentic assessment instrument validation based on Figure 1 show that media experts have the highest validation percentage, namely the relevance indicator with an average of 87%, subject matter experts' the completeness indicator is 87% and the practicality indicator completeness is 89%.

Figure 1
The Feasibility of Expert Validation on Authentic Assessment Instruments Through Virtual Laboratory Learning



Each validation in Table 4 showed that the authentic assessment instrument was very valid, with an average percentage value of 84%. These results were used to improve performance assessment instruments and portfolios, regarding the experts' judgments. They were also used to observe students' scientific performance, with improvements being performed according to the validator's suggestions. Furthermore, reliability specifically represented the quantity of error variance with various estimated values, for instance, test-retest, generalizable theory, and internal consistency.

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Table 4
Details of Research Instrument Categories

Subjects	Indicators	Score (%)	Interpretation
Assessment expert	Relevance, Completeness, Accuracy, and Clarity	88.0	Very valid
Linguist	Completeness, Legibility, Clarity, Appropriateness, and Accuracy	78.0	Valid
Practitioner/elementary school teacher	Accuracy (Effectiveness and Efficiency), Practicality, Clarity, and Completeness	85.0	Very valid
	Average	**84.0**	**Very valid**

The small-scale trial data conducted on 11th-grade students in Table 5 also showed different results in each indicator. From the small-scale test, *N*-gain the average value increase in the students' scientific performance was 0.7 and observed in the high category.

Table 5
N-gain of Gender Difference in Students' Scientific Performance

Participant	Gender	Pre-test	Post-test	Gain	N-gain	Average	Category
Experiment class	Female	3.5	4.6	1.5	0.73	0.7	High
	Male	3.2	4.4	1.8	0.67		

Data on students' scientific performance scores in Figure 2 shows the difference in pre-test and post-test scores, where the inference indicator has the highest score, namely 86 compared to other indicators.

Figure 2
Small-Scale Trial of Student Scientific Performance

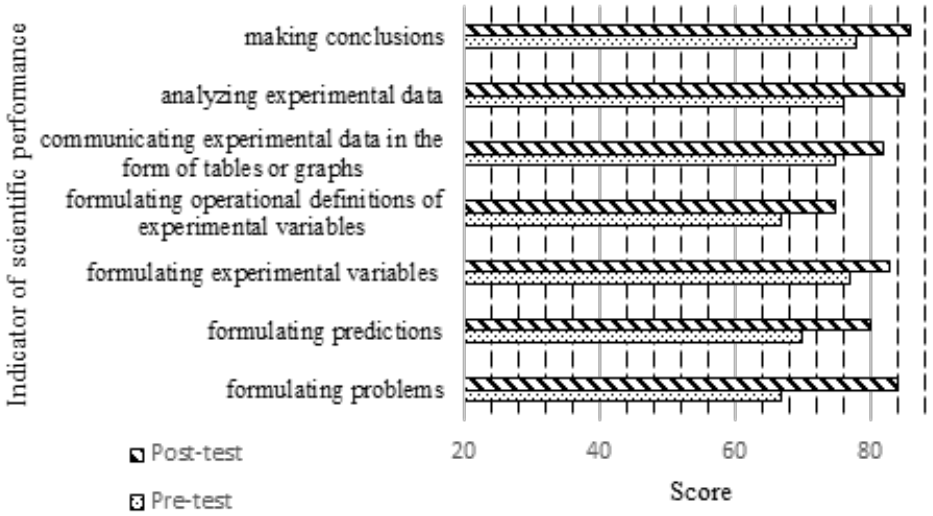

Table 6 shows the independent sample *t*-test is significant difference in increasing students' scientific performance in the groups in the pre-test for females and males ($t = 0.06$ and $p = .05$). However, in the post-test, there was a significant difference ($t = -1.7$, $p < .05$) between females and males.

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Table 6
t-statistic of Gender Difference in Students' Scientific Performance

Participant	Gender	Pre-test					Post-test				
		N	*M*	*SD*	*t*	*p*	*N*	*M*	*SD*	*t*	*p*
Experimental class	Female	55	3.5	0.89	0.06	.05	55	4.6	1.24	-1.7	< .05
	Male	63	3.2	0.78			63	4.4	1.12		

Qualitative Results

At the end of the study, the results of student responses to the application of authentic assessment through virtual laboratory learning towards improving scientific performance gave the most answers on practicality and completeness. The student responses are then described in the form of a comment including:

Student A: *I think the authentic assessment is useful. It helps to improve my performance skills when we have a portfolio of assignments and step-by-step projects for several weeks.*

Student B: *More time to think up ideas for topics about chemistry; more time to write and fix errors; get more information for the topic of acid-base material, after step by step, I corrected my writing even though there are still some mistakes.*

Student C: *Authentic assessment focuses more on the activities that I do and I become more aware of what I lack in understanding the material.*

Discussion

In the development of authentic assessment, an instrument is considered appropriate for use in high school, because there is an evaluation that can measure student performance in realistic tasks, relevant situations, or problems that are useful and meaningful. This shows that the use of authentic assessment can measure students' abilities during virtual practicum activities. Our findings show that acid-base learning is a much-needed lesson using a virtual laboratory. Virtual laboratories can display real theories and experiments without direct application in the laboratory room. The advantage is that teachers can save time in giving material to students. Virtual learning by helping virtual laboratories that can make learning interesting to increase student motivation in enjoying the learning being carried out (Estriegana, 2019).

After implementing the acid-base virtual laboratory, this study also revealed that authentic instruments are very feasible to use with the highest completeness indicators. The completeness of authentic assessment instruments is marked by indicators for each assessment, namely scientific performance and project-based rubrics. This finding agrees that performance assessment and project-based rubrics, as well as concept maps, need to be present in authentic assessments, to observe students' cognitive and psychomotor aspects (Salirawati et al., 2021). The performance appraisal category has response development and product evaluation (Said, 2020). This shows that performance appraisal and process-focused assessment help in teaching and learning activities in the classroom.

Furthermore, the scientific performance data shown in Table 5 of 0.71 reveal that there is an increase in student performance after implementing virtual laboratory learning. As expected, student performance assessment allows students to show their abilities, because they can distinguish between methods of conducting real and virtual practicums. This assessment is essentially carried out to equip students with real abilities because individual life is a process full of creating and solving problems to produce new problems. Under these circumstances, performance and portfolio assessments are critical to tracking progress toward those goals.

The highest student performance assessment score is also found in the conclusion indicator, with an N-gain of 0.78. Based on these results, the authentic assessment instrument developed can measure scientific performance from the highest to the lowest ability. This is due to the ability of performance appraisal to assess students' knowledge, attitudes, and skills. In agreement with earlier research that performance appraisal has future implications for students regardless of level, developing a foundation for problem-solving, independent learning, and constructive collaboration (Barber et al., 2015). As a task, this learning tool also requires students to show some meaningful realistic performances, related to the application of knowledge, understanding, and skills (Ernawati & Sujatmika, 2021; Price et al., 2010; Sulistyo et al., 2020).

This study found the fact that performance appraisal allows students to show their abilities because they can distinguish between methods of doing a real and virtual practicum. The results of this study are the validity of authentic

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assessment instruments that can increase students' critical thinking skills by 0.532 points, with a significance and R2 of 0.00 and 0.974, respectively (Damayanti et al., 2017). In addition, higher-order thinking and real-world problem-solving are two important elements in the development of authentic assessment (Azim, 2012; Basori & Mubarok, 2020). Several other reports also show that performance appraisal improves students' competency in practicum because rubric indicators represent all aspects of practicum implementation. These indicators are then able to overcome the problems encountered in biology practicum activities (Ramadhan & Suyanto, 2020; Sudrajat, 2012). In the virtual laboratory learning process, the increased scientific achievement is shown by students directly completing tasks through the applications provided at the stage of formulating experimental variables. Completion of assignments is also emphasized in investigations carried out by students starting from the pattern of determining the pH. Through the application of PhET simulations on https://phet.colorado.edu/ in a virtual laboratory, it is possible to distinguish strong acids from weak acids as shown through project appraisal analysis using a portfolio. There are obstacles in carrying out authentic assessments using virtual laboratories, where only some teachers understand the technology and run virtual laboratory applications, so it takes a long time when learning takes place. Even so, the final grades of students increased even though the school was experiencing limitations in providing practicum tools and materials. This is because students are enthusiastic about getting this new learning model. In line with Ali et al. (2022), an alternative practicum is carried out with using materials and limited laboratory equipment.

The use of authentic assessment through virtual laboratory learning is expected to be able to provide active learning solutions to improve student learning outcomes. Authentic assessment through the virtual laboratory is relevant enough to be implemented so that it becomes a solution to limited learning resources. The process of virtual laboratory activities is also a part that needs more attention, considering that the interface in the virtual laboratory is the only form of communication between the practitioner and the teacher. The existence of a proper and systematic assessment process will greatly influence the conclusion, namely whether the learning objectives are achieved.

Conclusions and Recommendations

The findings of this study reveal that the application of authentic assessment through virtual laboratory learning is appropriate for use by teachers in schools, especially in expressing students' scientific performance. The scientific performance of students has increased significantly with the high category on several indicators displayed. These results make a positive contribution to revealing students' skill abilities during virtual practicum activities. This finding also has a real impact on teachers who implement virtual laboratories in class. Virtual laboratories can display real theories and experiments without direct application in the laboratory room. The advantage is that teachers can save time in giving material to students. Even though there are several obstacles, namely only some teachers who understand technology, this makes a separate motivation for teachers in developing learning innovations. The use of complete and flexible assessments can make it easier for teachers to conclude students' final grades. However, in the process of applying the assessment, the teacher takes a long time to fill in the value manually. Finally, it can be recommended to use technology in implementing assessments, especially performance assessments so that they focus more on improving students' scientific performance and shortening the teacher's time in the assessment process.

Limitations

This research is limited to the feasibility test of the authentic assessment that is used, namely only observation sheets of assignments and portfolios as well as scores for improving the scientific performance of students studying in 11th-grade. The virtual laboratory used is also limited to acid-base material using the PhET simulation application on https://phet.colorado.edu/.

Declaration of Interest

The authors declare no competing interest.

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Muhammad Yakob
M.Pd in Department of Physic Education, Faculty of Teacher Training and Education, Samudra University, Langsa, Indonesia.
Email: myakob@unsam.ac.id
ORCID: https://orcid.org/0000-0002-5982-8983

Ratih Permana Sari
(Corresponding author)
M.Pd in Department of Chemistry Education, Faculty of Teacher Training and Education, Samudra University, Langsa, Indonesia.
Email: ratihps@unsam.ac.id
ORCID: https://orcid.org/0000-0003-3338-818X

Molani Paulina Hasibuan
M.Pd in Department of Chemistry Education, Faculty of Teacher Training and Education, Samudra University, Langsa, Indonesia.
Email: molanipaulinahsb@unsam.ac.id
ORCID: https://orcid.org/0000-0002-9664-784X

Nahadi Nahadi
PhD, Professor, Department of Chemistry Education, Faculty of Mathematics Education and Natural Science, Indonesia University of Education, Bandung, Indonesia.
Email: nahadi@upi.edu
ORCID: https://orcid.org/0000-0002-0975-7419

Sjaeful Anwar
PhD, Lecturer, Department of Chemistry Education, Faculty of Mathematics Education and Natural Science, Indonesia University of Education, Bandung, Indonesia.
Email: sjaefulanwar@upi.edu
ORCID: https://orcid.org/0000-0003-3708-5936

R. Ahmad Zaky El Islami
M.Pd. in Natural Sciences Education, Assistant Professor, Department of Science Education, Faculty of Teacher Training and Education, Sultan Ageng Tirtayasa University, Serang, Indonesia.
Email: zakyislami@untirta.ac.id
ORCID: https://orcid.org/0000-0002-5730-7658